Set 31: Reaction Stoichiometry Part II

Skill 31.01: Solve mole-mole stoichiometry problems
Skill 31.02: Solve mole-mass stoichiometry problems
Skill 31.03: Solve mass-mole stoichiometry problems
Skill 31.04: Solve mass-mass stoichiometry problems

Figure 1. Steps for solving the four types of stoichiometry problems

Type	Description	Steps
mole –mole	In *mole-mole* problem, you are given the moles of one substance and asked to calculate the moles of another substance in the chemical reaction.	moles given → moles unknown
mole-mass	In a *mole-mass* problem, you are given the moles of one substance and asked to find the mass of another substance in the chemical reaction	moles given → moles unknown → mass unknown
mass – mole	In a *mass-mole* problem, you are given the mass of one substance and asked to find the moles of another substance in the chemical reaction	mass given → moles given → moles unknown
mass –mass	In a *mass-mass* problem, you are given the mass of one substance and asked to find the mass of another in the chemical reaction	mass given → moles given → moles unknown → mass unknown

Skill 31.01: Solve mole-mole stoichiometry problems

Skills 31.01 Concepts

In mole-mole stoichiometry problems, you are asked to calculate the number of moles of one substance given the moles of another. According to figure 1, the steps involved are as follows:

moles given → moles unknown

According to the "steps" above, in order to calculate the number of moles of unknown, a conversion factor that relates the moles of unknown to the moles given is needed.

The following example, illustrates how this is done:

Example

Marshmallows (M_2) react with hot tamales (T_2) according to the following equation.

$2M_2 + T_2 \rightarrow 2M_2T$

If 2.0 moles of hot tamales react with excess marshmallows, how much in moles of MarshmallowHotTamalide can be made.

Solution

Step 1: identify the unknown: moles M_2T

Step 2: identify the given: 2.0 moles T_2

Step 3: identify the mole ratio between the unknown and the given:

$$\frac{2 \text{ mole } M_2T}{1 \text{ mole } T_2}$$

Step 4: multiply the moles of given by the mole ratio:

$$2 \text{ moles } T_2 \left| \frac{2 \text{ mole } M_2T}{1 \text{ mole } T_2} \right| 4 \text{ moles } M_2T$$

Skill 31.01 Example 1

Atmospheric oxygen reacts with nitrogen in automobile engines to produce NO, a poisonous greenhouse gas

$O_2 + N_2 \rightarrow 2NO$

If 5 moles of nitrogen react, how much oxygen gas in moles is consumed?

Given	Mole ratio	Unknown

Skill 31.02: Solve mole-mass stoichiometry problems

Skill 31.02 Concepts

In mole-mass stoichiometry problems, you are asked to calculate the mass of one substance given the moles of another. According to figure 1, the steps involved are as follows:

moles given → moles unknown → mass

According to the "steps" above, in order to calculate the mass of unknown, a conversion factor that relates the moles of unknown to the moles given is needed, and a conversion factor that relates the mass of unknown to the moles of unknown is needed.

The following example, illustrates how this is done:

Example

Marshmallows (M_2) react with hot tamales (T_2) according to the following equation.

$2M_2 + T_2 \rightarrow 2M_2T$

If 2.0 moles of hot tamales react with excess marshmallows, what mass of MarshmallowHotTamalide can be made.

Solution

Step 1: identify the unknown: mass M_2T

Step 2: identify the given: 2.0 moles T_2

Step 3: identify the mole ratio between the unknown and the given:

$$\frac{2 \text{ mole } M_2T}{1 \text{ mole } T_2}$$

Step 4: Identify the molar mass of the unknown,

1 mole M_2T = 2(5.5) + 24.0 = 35.0 g

Or another way to right this is as follows,

$$\frac{1 \text{ mole } M_2T}{13 \text{ g}}$$

Step 5: multiply the moles of given by the mole ratio and the molar mass

2 moles T_2	2 mole M_2T	35 g	140.0 g
	1 mole T_2	1 mole M_2T	

Skill 31.02 Example 1

In the lower atmosphere where we live, NO and UV light catalyze the production, O_3 from O_2 as shown,

$3O_2 \rightarrow 2O_3$

If 10.0 moles of oxygen react, how much in grams of O_3 (1 mole = 48 g) is produced?

Given	Mole ratio	Molar mass Unknown	Unknown

Skill 31.03: Solve mass-mole stoichiometry problems

Skill 31.03 Concepts

In mass-mole stoichiometry problems, you are asked to calculate the moles of one substance given the mass of another. According to figure 1, the steps involved are as follows:

mass given → moles given → moles unknown

According to the "steps" above, in order to calculate the moles of unknown, a conversion factor that relates the moles of given to the mass given is needed, and a conversion factor that relates the moles of unknown to the moles of given is needed.

The following example, illustrates how this is done:

Example

Marshmallows (M_2) react with hot tamales (T_2) according to the following equation.

$2M_2 + T_2 \rightarrow 2M_2T$

If 12.0 g of hot tamales react with excess marshmallows, how many moles of MarshmallowHotTamalide can be made.

Solution

Step 1: identify the unknown: M_2T

Step 2: identify the given: 12.0 g T_2

Step 3: identify the molar mass of the given,

1 mole T_2 = 2(24) = 48.0 g

Or another way to right this is as follows,

$$\frac{1 \text{ mole } T_2}{48 \text{ g}}$$

Step 4: identify the mole ratio between the unknown and the given:

$$\frac{2 \text{ mole } M_2T}{1 \text{ mole } T_2}$$

Step 5: multiply the mass of given by the mole-mass conversion factor and the mole ratio

$$12.0 \text{ g } T_2 \left| \frac{1 \text{ mole } T_2}{48.0 \text{ g } T_2} \right| \frac{2 \text{ mole } M_2T}{1 \text{ mole } T_2} \left| 0.50 \text{ mole } M_2T \right.$$

Skill 31.03 Example 1

How much, in moles, of 1-chloropropane (C_3H_7Cl) is produced if 400. g of C_3H_8 (1 mole = 44 g) react with excess chlorine gas according to the equation

$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$

Given	Molar mass given	Mole ratio	Unknown

Skill 31.04: Solve mass-mass stoichiometry problems

Skill 31.04 Concepts

In mass-mass stoichiometry problems, you are asked to calculate the mass of one substance given the mass of another. According to figure 1, the steps involved are as follows:

mass given → moles given → moles unknown → mass unknown

According to the "steps" above, in order to calculate the mass of unknown, a conversion factor that relates the moles of given to the mass given is needed, a conversion factor that relates the moles of unknown to the moles of given is needed, and a conversion factor that relates the mass unknown to the moles unknown is needed.

The following example, illustrates how this is done:

Example

Marshmallows (M_2) react with hot tamales (T_2) according to the following equation.

$2M_2 + T_2 \rightarrow 2M_2T$

If 12.0 g of hot tamales react with excess marshmallows, how much in grams of MarshmallowHotTamalide can be made.

Solution

Step 1: identify the unknown: M_2T

Step 2: identify the given: 12.0 g T_2

Step 3: identify the molar mass of the given,

1 mole T_2 = 2(24) = 48.0 g

Or another way to right this is as follows,

$$\frac{1 \text{ mole } T_2}{48 \text{ g}}$$

Step 4: identify the mole ratio between the unknown and the given:

$$\frac{2 \text{ mole } M_2T}{1 \text{ mole } T_2}$$

Step 4: Identify the molar mass of the unknown,

1 mole M_2T = 2(5.5) + 24.0 = 35.0 g M_2T

Or another way to right this is as follows,

$$\frac{1 \text{ mole } M_2T}{13 \text{ g } M_2T}$$

Step 6: multiply the mass of given by the mole-mass conversion factor and the mole ratio and the mass-mole conversion factor

12.0 g T_2	1 mole T_2	2 mole M_2T	13.0 g M_2T	6.5 g M_2T
	48.0 g T_2	1 mole T_2	1 mole M_2T	

Skill 31.04 Example 1

Laughing gas (nitrous oxide, N_2O) is sometimes used as an anesthetic in dental work. It is produced when ammonium nitrate is decomposed according to the reaction,

$NH_4NO_3 \rightarrow N_2O + 2H_2O$

How many grams of NH_4NO_3 (1 mole = 80 g) are required to produce 33.0 g of N_2O (1 mole = 44 g)?

Given	Molar mass given	Mole ratio	Molar mass Unknown	Unknown

Set 31.0 Summary

In the early stages of solving stoichiometry problems it is useful to know what steps to combine for a given type of problem. For this reason, I have provided figure 2. Keep in mind however, you will not be permitted to use this on quizzes or exams. Only through practice will you acquire independence from this guide.

Figure 2. How to solve the four types of stoichiometry problems

Type	Steps
mole –mole	moles given x mole ratio $\frac{\text{unknown}}{\text{given}}$ = moles unknown
mole-mass	moles given x mole ratio $\frac{\text{unknown}}{\text{given}}$ x $\frac{\text{molar mass unknown (g)}}{\text{1 mole unknown}}$ = mass unknown (g)
mass – mole	mass given x $\frac{\text{1 mole given}}{\text{molar mass given (g)}}$ x mole ratio $\frac{\text{unknown}}{\text{given}}$ = moles unknown
mass –mass	mass given x $\frac{\text{1 mole given}}{\text{molar mass given (g)}}$ x mole ratio $\frac{\text{unknown}}{\text{given}}$ x $\frac{\text{molar mass unknown (g)}}{\text{1 mole unknown}}$ = mass unknown (g)